Water Resources Sustainability Project
(WRS)

Pilot Project for Control of Soil Erosion in the Oued Nakhla Watershed

Annual Progress Report
January 1st to December 31st, 2000

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Ministry of Environment

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1. Progress in Developing Project Partnerships and Coordination

The Workplan for implementation activities in Oued Nakhla was signed in February of 2000 by the following partners who represent the National Coordinating Committee for the project:

- Moroccan Ministry of the Environment
- Moroccan Ministry of Agriculture
- PREM
- Agency for the Development of Northern provinces
- Tetouan provincial government

The workplan contains agreements for the following work:

- Olive tree plantings in zones 2 and 3
- Planting 5,000 acacias and carobs along 1.5 km of ravines in zone 1
- Rehabilitation plan for irrigation networks in zone 1
- Improvement of springs in zones 2-3
- Construction of cuvettes around olive trees in zones 1-3
- Installation of grass strips between olive trees
- Establishment of 15 demonstration trials for wheat and forage crops
- Planting fruit trees along the edges of irrigated terraces in zone 1
- Carob tree plantings on 92 ha of public land in the degraded mattoral of zones 1-2
- Rehabilitation of private rangeland and public mattoral in zones 1-4
- Development of beekeeping production systems in zone 4
- Distribution and management of Spanish goats
- Distribution of improved cookstoves and formation of women's cooperatives
- Conduct on-site training and field trips for farmers on above topics

A workshop dealing with the lessons learned from the pilot project activities was held from November 15-16, 2000 at the National School of Agriculture in Meknes. About twenty participants attended the workshop, representing PREM project leaders and consultants, the Departments of Environment and Agriculture, the DPA in Tetouan, the Work Center personnel from Oued Nakhla, the Souss-Massa water project, and USAID. The workshop was organized into a plenary session, followed by three workgroup discussion sessions dealing with the successes and difficulties encountered on Institutional aspects of the project, direct implementation actions, and indirect actions.

At the Institutional level, workshop participants agreed that project partners are gaining valuable experience and confidence in implementing project activities and are working closely with each other. The project takes a multi-disciplinary and multi-institutional approach to achieving project objectives. A spirit of good cooperation exists among project partners. Joint financing of project activities by project partners is now occurring on a regular basis, partly because project objectives are consistent with Moroccan agency priorities. A good example of this is money provided by the DPA for labor costs associated with constructing cuvettes around olive trees on 240 ha of newly planted land in zones 2 and 3.

From an institutional point of view, the main need for improvement is to develop better participation and cooperation with the Regional Department of Water and Forests (DREF).

Their expertise is needed in developing a better management plan for the public lands in the degraded mattoral.

2. Progress in Developing Village and Farmer Partnerships

PREM consultants Dr. Rachidi, Dr. Mounsif, and Dr. Serhane, along with Mme Bolata from the Ministry of Environment, had regular meetings during the year 2000 with Community Associations and farmers in each of the four project zones. In general, they meet twice with the Community Associations before implementation of any project activity, and once afterwards. PREM consultants and personnel also regularly meet with governmental project cooperators at the county and provincial levels.

Village committees play a crucial role in conveying farmer needs to project partners. For example, the drought of the last 2 years caused serious threats to the sustainability of olive tree plantations. Farmers proposed construction of reservoirs to be used in storing water from several springs. This sentiment was conveyed to project leaders through the Village Committees. Project partners responded to farmer needs in a direct, rapid fashion by constructing 7 storage basins in zone 1. As a result, farmers now have an emergency source of irrigation water for olive trees, reducing mortality.

3. Progress in Education and Training Activity

The Work Center in Beni Karrich, along with PREM consultants, continues to provide high quality on-site training for project beneficiaries in the Oued Nakhla watershed. The effectiveness of these training sessions is high, due to reliance on hands-on demonstrations, field visits, use of photographs, and handouts. The training sessions have reached at least 398 farmers in the year 2000. Surveys of farmers showed that they were very satisfied with the training sessions.

The Work Center conducted several workshops on construction of cuvettes around olive trees, starting in April and continuing through the end of June. At these workshops there were demonstrations showing how wide and deep to make cuvettes, and how to line them with rocks to stabilize the lower edge. The benefits of cuvettes were explained to farmers. These benefits include capture of water to allow better growth of olive trees, collection of soil eroding from upslope cultivated areas, and a well-defined area in which fertilizer can be placed.

In June a workshop was held on beekeeping techniques for 10 cooperators in zone 4. The workshop was led by Dr. Serhane from Agadir. The workshop focussed on methods for recovery of honey, preventative treatment of diseases and pests that affect bees, and supplemental feeding for bees during periods of drought.

In June there were two workshops on goat production and management techniques. These were led by Dr. Mohamed Mounsif, an animal scientist from ENA Meknes. The workshops focussed on feed and nutrition, and on sanitation and hygiene.

Several training activities focussed on the Woman's Association in zone 1. In January, discussions were held with these women on improved cookstoves. Much of the discussion involved the issue of individual versus collective cookstoves. The Work Center proposed providing 4 collective cookstoves, and after some hesitation, this approach was agreed upon by the Village Committee. A field trip to a Woman's Cooperative in Chefchaouen was held in late January to observe a successful situation involving collective cookstoves. Introduction of such cookstoves can reduce the amount of wood burned by 38%, equivalent to 4.9 tons/yr for each household. Also in January, the Woman's Association in zone 1 discussed options for raising small animals to supplement household income. The women expressed an interest in chickens and rabbits. In March representatives of the Woman's cooperative, the PREM project, and the Work Center met with the Judge in Beni Hassan.

Training sessions were held for 21 farmers on grass buffer strips between olive trees at demonstration sites on 2 ha of private land. This practice has great potential to reduce erosion by trapping sediment and encouraging contour tillage and farming practices. It also has great potential to provide high quality forage material for animals if cut during the fall, stored, and fed to animals during the winter months. To the farmers and members of the Work Center, this is a new technique, which is viewed as experimental in nature. There is significant hesitation on the part of farmers in adopting this technique, unless its economic benefit to them and their animals can be demonstrated. Grass seed and fertilizer to establish 2 ha of grass buffer strip demonstrations were provided to farmers at the training session. A mixture of dactylis glomerata and festuca are being planted at a rate of 500 kg/ha seed in a band that is roughly 50 cm wide. Next year more emphasis should be placed on testing other varieties of forage to increase farmer adoption rates.

Several workshops were held that deal with improved methods for cultivation of olive trees. One workshop addressed application of fertilizer. Farmers were informed of the benefits of fertilization, and the proper rates and times of application. Another series of six workshops dealt with control of diseases and pests in olive trees. The first series of three workshops dealt with spraying olives against "Oiel de Paon, Teigne, Cochenille Noir and Psylle." Farmers were trained to understand the phenologic indications of this disease, shown photos of diseased leaves, its life cycle, methods of control, product mixing, and safety precautions in spraying, mixing, and disposing of product. Farmers were taken to a diseased olive tree to view the problem, and then showed how to spray for control using a sprayer purchased by the project for farmers. A second series of three workshops dealt with spraying olives against white fly. The approach used in training farmers to control this disease were similar to those used in the first series of workshops. After the workshops, many farmers sprayed their own trees. For instance, at the workshops in zone 2, 13 participants treated 1,729 olive trees representing 10% of the trees in that zone.

The Work Center established several crop production demonstration sites during the months of November and December in each of the four project zones. These demonstrations are of two major types, namely; wheat variety trials and forage variety trials.

The wheat variety trials involve three zones. In zone 1 (near Bettara) there is 0.5 ha of soft white wheat (variety Achetar). In zone 2 (near Azzemour and Bouattou) there is 0.5 ha of soft white wheat (variety Achetar), 0.5 ha of soft white wheat (variety Marchouch), and 0.5 ha of soft white wheat (variety Kenz). In zone 3 there is 0.5 ha of soft white wheat (variety Marchouch). These demonstrations involve seeding rates of 1 qx/ha, and fertilizer management practices involving 1.5 qx starter fertilizer with 0.5 qx broadcast. A 0.25 ha control area with traditional management practices, and a cultural sequence involving fertilize-plant-plow) accompanies each of the demonstration plots. The yield of the demonstration plots ranges from 11-16 qx/ha, which is four times the yield on traditional farm lands. About 65 farmers were taken to these demonstration plots to observe the advantages of improved management techniques for wheat production.

The forage demonstration trials involve three 0.5 ha parcels in zones 2, 3, and 4. There were 3 cooperators for these trials. In each trial, a mixture of 40% wheat (variety Drira) and 60% vetch (variety 6225) is planted at a rate of 200 kg/ha seed. Forage yields ranged from 15-22 tons/ha. This forage can provide animals with carbohydrates and protein. Farmers must be taught to collect and store the harvested crop for feeding of their animals during the winter months. Thirteen farmers were taken to the forage demonstration plots to learn improved methods of forage production.

4. Project Implementation Activities

4.1: Direct Actions

4.1.1: Olive Tree Planting

The DPA Work Center at Beni Karrich, under the supervision of PREM consultant Mr. Rachidi, took the lead responsibility in organizing the olive tree planting campaign for the year 2000, including training, identifying land parcels to be treated, surveying land parcels, and monitoring success of the tree planting campaign. Approximately 22,000 locations were identified on 110 ha of land in zones 2 and 3 for olive tree plantings. An additional 30,100 locations were also surveyed in order to plant an additional 215 ha with olives beyond zone 3 in response to a great demand for trees from the villagers. A total of 83,000 olive trees have been planted in zones 1, 2 and 3 on 550 ha of land through the middle of November, 2000. By the end of the year 2000, it is anticipated that a total of 765 ha of land will be planted with 113,100 olive trees. Another 12,000 sites in zones 1-3 will be replanted with olive trees to replace trees that have died during the two years of drought or have been illegally eaten by grazing livestock.

As in the previous year, the spacing between trees along the contour was 7 m, and the vertical drop between planted contour lines was 2 m. Due to the irregularity of the terrain and land ownership patterns, this was not possible in all cases. This planting pattern was designed to reduce the horizontal spacing between planted contour lines on steeper slopes (as small as 6 m), and increase the horizontal spacing on flatter slopes (as large as 14 m). This would allow the farmers on the steeper lands, which are very vulnerable to erosion, to eventually phase out cereal production by relying on the income from the olive trees. Locations of trees in adjacent contour lines were offset so that runoff water from the unplanted region on the upper

slope would be intercepted by a tree on the lower slope. Difficulties in keeping to a regular system of tree spacing occurred on small irregularly shaped land parcels (some as small as 16 m^2), especially near ownership boundaries. Trees were kept far enough away from boundaries to reduce disputes between landowners.

Farmers are extremely pleased with the olive tree planting program. They understand that when these trees begin producing olives, the household income of project cooperators has the potential to increase significantly. Cooperators in each zone have requested that the project provide a few collective olive oil extraction units to process the olive crop once significant quantities of olives are produced.

One difficulty associated with the olive tree plantations is the lack of grass forage strips planted between trees. Only 2 ha of grass strips have been planted to date. Farmers do not understand the value of these strips for forage production or erosion control. The strips create difficulties for the farmers in tilling their land, since they cannot plow up and down the slope with the strips in place. Additional demonstration plots and training sessions are required to increase the adoption of this valuable practice.

4.1.2: Protection of Olive Tree Plantations With Guards:

Grazing by goats has been largely controlled during the third year of the project. This was achieved by hiring four guards at 700 DH/month to protect trees from animal grazing. Trees in most areas of zones 1, 2, and 3 are quite healthy. A visual survey of olive tree plantings during a field trip in November showed that there is considerable wheat residue and weedy growth remaining on lands where olive trees were planted, indicating that animals have not grazed these lands since harvest. In contrast, land without olive trees has very little crop residue.

4.1.3: Development of Supplemental Irrigation Water Sources for Olive Tree Plantings:

Damages by drought during the summer have largely been ameliorated in zone 1 after construction of 7 water reservoirs by PREM contractor Mr. Brahim Hilali. Each reservoir has a water storage capacity of 10 cubic meters. Visual inspection of reservoirs during November of 2000 showed that they were full of water, despite the two years of drought. The water is supplied by springs, which have been developed and improved by PREM project contractors. Springs are lined by rocks and have a concrete receptacle on the ground from which water is piped by gravity to each reservoir.

Reservoirs are constructed with a concrete base and are enclosed by sheet metal, there is a pipe to prevent overfilling of the reservoir. Each reservoir also has an outlet pipe with a faucet to control flow of water into a receptacle. The receptacle can then be taken to the field and used to irrigate each tree. Villagers also collect water for household uses.

Villagers in zones 2 and 3 also wish to have supplemental sources of irrigation water. The DPA has identified 13 springs which have a potential for being improved and where reservoirs can be built. These springs will be visited in December to assess the rate of baseline water flow. Springs with the greatest baseline flows will be improved and have

reservoirs constructed to collect and store the water. Springs which are dry will not be improved.

4.1.4: Construction of Cuvettes Around Planted Olive Trees:

The Work Center at Beni Karrich has taken effective leadership in maintenance of existing cuvettes and installation of new cuvettes around planted olive trees. During an intensive training program from April to June, the Work Center motivated farmers to rebuild and maintain cuvettes around a majority of already planted olive trees. Farmers understand that properly maintained cuvettes capture runoff water that can be used to stimulate the growth of their trees. With Agricultural Development funds and National Promotion funds provided by the DPA, the Work Center and PREM were able to build new cuvettes around 32,000 olive trees on roughly 240 ha of newly planted land. In zone 3, thirty laborers were hired to help construct cuvettes. As a result, all of the 83,000 olive trees planted by the project now have cuvettes, a tremendous accomplishment, considering that after the first year of olive tree plantings no trees had cuvettes and farmers did not view cuvettes as being necessary.

4.1.5: Application of Fertilizer to Olive Tree Plantings:

Fertilizer for olive trees was applied to olive trees in zones 2 and 3 after construction or maintenance of cuvettes. Ammonium sulfate fertilizer was applied at a rate of 0.5 kg per tree.

4.1.6: Improved Access to Agricultural Management Tools:

Dryland agricultural lands in Oued Nakhla are managed using traditional methods, including wooden plows pulled by animal traction. Modern tools are generally not available for routine practices such as spraying of herbicides and insecticides, pruning trees, sawing or chopping wood, or plowing.

The Work Center has started to make available modern agricultural tools for loan to cooperators. PREM purchased 2 motorized sprayers, 50 hand sprayers, 50 pruning shears, 50 saws, and 5 axes for loan to cooperators through the Work Center.The Work Center has held an informal workshop with 21 farmers on the proper use of iron plows, but farmers find them heavy and awkward to use. There were plans to purchase 12 iron plows, each weighing 14 kg, but these have been abandoned due to lack of farmer interest. This is probably fortunate, since erosion rates could be increased two-fold if heavy metal plows were used up and down the slope. Instead of plows, the Work Center has decided to buy 50 planters to help ensure that seeds are not planted too deep to germinate.

4.1.7: Stabilization of Ravines

Check dams and gabions installed along 1.5 km of ravines in zone 1 have filled in with sediment and rocks from slumping banks along the ravine. These banks have been systematically planted at spacings of about 9 m in March and April of the year 2000 with 8,000 acacia and 5,000 carob tree seedlings. The acacias have survived through November, but 90% of the carob tree seedlings have died or are in very poor shape. The carob tree

seedlings were very small (less than 1 cm in height), and were susceptible to drought. The acacia seedlings were typically about 1 m in height, and were less susceptible to drought.

The systematic planting method of acacias left large areas along the ravines devoid of stabilizing vegetation. These bare areas are continuing to slump, generating tons of sediment that fills in behind dams and gabions. A planting campaign targeted to these bare areas is needed. These bare areas can be stabilized by planting three rows of acacias or oleanders across the bare soil.

4.2: Indirect Actions

4.2.1: Improvement of Goat Breeding Stock:

Improved goat breeding stock (Morceano) from Spain with the assistance of the Agence du Nord were distributed to farmers in four zones of the project on the first Tuesday of August, 2000. Under the supervision of the Judge in Beni Hassan, the local authorities, the Village Committees, PREM consultants, and the DPA at Tetouan, title was transferred to 24 breeders.

About 4,000 head of goats in the Oued Nakhla watershed were immunized by the DPA during two cycles in June and December of 1999 to prevent the spread of disease from unimproved to improved goats.

Another 26 Spanish goats are currently under quarantine in Mdiq. These will be distributed to another set of breeders within a period of 6 months.

4.2.3: Development of Beekeeping Production System:

During 1999 the Agence du Nord purchased 100 beehives for distribution in zone 4, where the mattoral is in very good condition for producing nectar needed by bees. They also purchased two sets of beekeeping equipment for use by a collective of 25 cooperators who manage the beekeeping operations. This equipment includes protective suits, knives, collectors, smokers, extractors, vats, and tubs. Also in 1999, The Work Center and DPA identified 25 cooperators who were willing to work together in managing the beekeeping operations.

The severe drought of 1999-2000 reduced the availability of flowers and nectar for bees, causing the loss of 25 hives through lack of food and increased susceptibility to diseases. These hives will be replaced in the coming months. Villagers in the beekeeping cooperative have lost some confidence in the potential economic benefits of beekeeping ventures. They realize the indirect benefits these operations have on erosion, because there is an incentive to protect the mattoral from wood cutting activities.

4.2.3: Rehabilitation of Rangeland and Degraded Mattoral

Plans for widespread rehabilitation of private rangeland and publicly owned degraded mattoral have been seriously delayed due to social attitudes. These attitudes include a lack of

understanding about the importance of erosion from the mattoral, and the traditional use of these lands for animal grazing. After reseeding rangeland and degraded mattoral it is necessary to protect these lands from grazing for a period of roughly one and a half years. Some of the villagers will not agree to protect the reseeded public mattoral for the necessary time period. Many villagers are willing to avoid grazing for this period, but unless everyone abides by the agreement, the reseeding project on public mattoral lands cannot be successful. Another factor leading to lack of success in rehabilitation of rangeland and the mattoral is the lack of participation by the DREF in planning and implementing these actions.

Reseeding of private rangelands occurred on 12.5 ha of land belonging to 8 cooperators in zone 2. This land was seeded at a rate of 5 kg/ha festuca and 3 kg/ha of glomerus dactyla. The land was plowed prior to seeding, and was fertilized with 50 kg/ha of 14-28-14 N-P-K fertilizer afterwards. Grass forage has shown good growth during the year 2000, despite the drought. These areas will be protected from grazing for the next year. Unfortunately, due to a lack of proper understanding that these grass forages are a perennial crop, the Work Center plowed some small areas of restored private rangeland. Also, due to improper training, one cooperator planted his forage seeds too deep, causing them to fail in germination. Altogether, forage crops have successfully germinated on only 4 ha of private rangeland.

4.2.4: Development of Irrigated Fruit Tree Production:

In preparation for distribution of fruit trees to owners of irrigated terraces, a workshop was held in January on fruit tree planting techniques. This workshop covered the four main varieties preferred by farmers, including apples, pears, quince and prunes. Planting techniques and watering techniques were explained to 32 cooperators. 10,000 trees have been obtained from the nursery, and will be planted on 20 ha of irrigated terraces in zone 1 during the next few months.

4.2.5: Rehabilitation of Irrigation Systems

The CPS developed a detailed workplan for rehabilitation of 2 km of irrigation networks in zone 1 at a projected cost of $70,000. Open channels will be lined with concrete, and losses of water at high gradient portions of the conveyance system will be reduced significantly. Implementation of this plan will commence during 2001.

5. Progress in Monitoring Erosion Losses

PREM consultant Mohamed Khatouri developed Geographic Information System (GIS) thematic coverages and applications for the Oued Nakhla watershed. The objectives of this work were to provide visualization capacities of project activities, to estimate impacts of project activities on erosion and sediment transport to the Nakhla Reservoir, and to assist in dissemination of project results.

Thematic layers which can be visualized using the GIS include:

- Nakhla Watershed boundary
- Nakhla Reservoir location, outline, and loss in capacity since 1961
- Clip art photo of Reservoir
- Digitized locations of streams and ravines in the Watershed
- Location of stabilized ravines
- Clip art photo of stabilized ravines
- Locations of soil erosion measurement plots
- Tables of soil loss values linked to erosion plots
- SPOT satellite images of the Watershed in 1995 at a scale of 1:25000
- Digitized elevation contour maps
- Locations of improved springs and reservoirs
- Locations of villages
- Locations of land parcels where rangeland improvements are demonstrated
- Locations where improved goat breeds have been introduced
- Clip art photo of improved goat breeds
- Location of Bettara Women's Association
- Clip art photo of women in the Association
- Boundaries of olive planting operations in zones 1-3
- Clip art photo of olive tree plantations
- Soil map of the Watershed, including 18 soil map units
- Linked table of soil properties measured for each soil map unit
- Land use map of the Watershed, including 7 land use units

For the purposes of estimating impacts of the project activities on soil erosion and sediment transport to the Nakhla Reservoir, these GIS layers were used to estimate parameters of the Universal Soil Loss Equation (USLE):

$$A = R K LS C P$$

where:

A is estimated annual soil loss
R is the rainfall erosivity factor
K is the soil erodibility
LS is the slope length and steepness factor
C is the cover management factor
P is the conservation practice factor

The rainfall erosivity factor was estimated by PREM consultant Mhammed Tayaa using two years of precipitation intensity and energy data at two sites in or near the Watershed. An R value of 144 was estimated for the upper portion of the watershed, somewhat greater than the value of 103 estimated by Dr. Tayaa for the project feasibility report.

The soil erodibility factor was estimated by Mhammed Tayaa based on a soil texture index (M) and organic matter content (OM) using the equation:

$$100K = 2.1 \times 10^{-4} \times (12\text{-}OM\%) \times M^{1.14} + 3.25 \times (S\text{-}2) + 2.5 \times (P\text{-}3)$$

In this equation it was assumed that the soil structure code (S) had a value of 2, and that the soil permeability code (P) had a value of 3. Values of K ranged from 0.05 to 0.44, with the higher erodibility values for sandy soils, and the lower values for silts and clays.

In general, erodibility values for silty soils are greater than values for sandy or clayey soils. Silt sized soil particles are moderately easy to detach and transport, whereas sandy particles are easy to detach but difficult to transport, and clayey particles are difficult to detach but easy to transport. Thus, the initial values for K estimated by Dr. Tayaa do not seem reasonable.

An improvement in the erodibility estimates was made by accounting for differences in soil permeability across the soil units in the watershed. PREM consultant Rachid Bouabid conducted a limited number of permeability tests on soils in the Watershed. Using these data, along with expert judgement based on soil texture and classification, PREM consultants Bouabid and Mulla assigned each soil map unit a permeability code rating ranging from 1 to 6, with the lower numbers representing soils with high permeability, and the higher numbers representing soils with lower permeability. These code values were used in a GIS script developed by Mr. Khatouri to improve the soil erodibility estimates.

Slope length and steepness (LS) factor values were estimated by Mr. Khatouri from the elevation contours and a flow accumulation algorithm developed for the Modified Universal Soil Loss Equation (MUSLE). The majority of the watershed has LS factors of approximately 10-40. Values for LS may still be over-estimated using this method for the irrigated terraces.

The cover management factor (C) was initially estimated by Dr. Tayaa for each land use practice studied in the erosion plots. Rates of soil erosion in the cultivated erosion plots are not representative of long-term rates in typical farmer fields because the erosion plots are not properly tilled, have dense weeds, and leak. In addition, drought conditions of the last two years are not representative of long-term climatic conditions, so the rainfall erosivity is too small. Therefore, the estimated C factors are from 2 to 3 orders of magnitude too small.

Improved estimates of the C factors for each land use practice were made by using data from erosion plots in Tunisia, and published values for similar crop rotations in USDA Handbook 537. The improved estimates for the C factor, along with estimates for the conservation management factor (P) are shown in Table 1 below:

Table 1: Universal Soil Loss Equation (USLE) Cover Management (C) & Conservation Practice (P) Factor Values

Land Use	Erosion C Factor	Erosion P Factor
Wheat-Legume-Fallow	0.6	1.0
Wheat-Legume-Fallow w/Olives - Cuvettes		
Immature Olive Trees	0.45	1.0
Mature Olive Trees	0.05	1.0
Wheat-Legume-Fallow w/Olives-Cuvettes-Stripcrop		
Immature Olive Trees	0.34	0.8
Mature Olive Trees	0.01	0.8
Irrigated Terraces	0.9	0.5
Degraded Mattoral	0.18	0.5
Dense Mattoral	0.01	0.5
Forest	0.005	0.5

Ultimately, accurate evaluation of erosion rates in Oued Nakhla can be obtained using the GIS data layers for USLE factors (R K LS C P) described above. Preliminary estimates of erosion were made in Rabat during November of 2000 with reasonably accurate values of R, LS, C, and P, but somewhat inaccurate K values. The average rate of erosion estimated without project interventions using the GIS was 104 tons/ha/yr. Erosion estimates will also be made after accounting for project interventions in the short- and long-term.

As an example of the impact of project activities on soil erosion, consider the following scenario. Olive trees with cuvettes have been installed on 550 ha of rainfed agriculture in zones 1, 2, 3, and beyond. This land has a rainfall erosivity of 144, a soil erodibility of 0.3, and an LS factor of 8. With conventional rainfed management before the project implementation activities (C factor 0.6, P factor 1.0) erosion rates on this land would have been about 207 ton/ha/yr. After olive tree plantings (C factor 0.45, P factor 1.0) erosion rates have been reduced 25% to 156 ton/ha/yr. In seven to ten years, when the olive trees mature (C factor 0.05), erosion rates will be reduced by 92% to 17 ton/ha/yr.

The impacts of this scenario on erosion and sediment transport in Oued Nahkla can be evaluated after multiplying erosion rates by the area of land planted to olive trees (550 ha). With conventional management, these 550 ha produce 114,048 tons of eroded sediment annually. With immature olive trees and cuvettes, eroded sediment decreases to 85,635 tons. When these trees reach maturity, eroded sediments will decrease to 9,515 tons.

The total mass of sediment conserved with olive tree plantings is 28,413 tons for immature trees and 104,533 tons for mature trees. These results are summarized in Table 2.

Table 2: Estimates of Project Impacts on Erosion In Oued Nakhla Before and After Olive Tree Plantings with Cuvettes on 550 ha of Fields With a Wheat-Legume Rotation

	Wheat-Legume	Immature Olive Trees	Mature Olive Trees
Erosion Rate (t/ha/yr)	207	156	17
Erosion Mass (t/yr)	114,048	85,635	9,515
Erosion Reduction (t/yr)	-	28,413	104,533
Erosion Reduction (%)	-	25%	92%

At a sediment delivery ratio of 0.15, a typical value for a 114 km^2 area watershed, these 550 ha of land deliver 17,107 tons of sediment annually to the Nakhla Reservoir under conventional management, 12,845 tons under immature olive trees, and 1,427 tons under mature trees. In the long-term (under mature trees), these 550 ha of land with mature olive trees will deliver to the Reservoir 15,680 tons/yr of sediment less than the same land under conventional management. Since the Reservoir is currently filling in at a rate of about 160,000 tons of sediment per year, the 550 ha of land planted with olive trees will reduce the rate of infilling by 10% per year.

Ravines are a significant source of sediment in zone 1. Many of the gabions and check dams are completely filled with large stones and sediment, thus reducing the operating efficiency of these structures. The source of this debris is slumping banks along the ravines.

PREM consultant Mhammed Tayaa conducted repeated topographic surveys along 95 cross-sections of ravines extending for almost 500 m in zone 1. Subtraction of the cross-section surveys on successive dates gives the cross-sectional area of soil lost by slumping of the banks along ravines. The average rate of soil loss from these ravines was 345 tons/yr for each linear kilometer of ravines. The catchment area for ravines in this survey was an area of 5.2 ha. Thus, the ravines produce an average rate of 33 tons/ha/yr of soil loss. In comparison, the surrounding agricultural land in conventional management has an average rate of 207 tons/ha/yr of soil loss. Thus, ravines produce less soil loss than agricultural land.

6. Progress Towards Indicators of Project Success in 2000

The pilot project has generally been on target with respect to indicators of progress identified in the 2000 Workplan (see Table 3).

Among the salient accomplishments of PREM and its project partners in 2000 are the following:

- Signed Project Workplan with Ministries of Environment and Agriculture, Agency for Development of the North, and the Tetouan Provincial Government.

- Conducted workshops covering 11 topics relating to project implementation activities. These topics included construction of cuvettes, beekeeping, goat production, grass strips, agricultural implements, improved crop production techniques for wheat and forages, disease and pest control in olives, cookstoves, and replication of project activities.

- Established 9 demonstration trials in four project zones concerning wheat and forage production techniques. These demonstrations address issues such as seeding rate, variety performance, fertilizer management, and tillage management.

- Planted 21,700 olive trees on 110 ha of cultivated dryland in zones 2 and 3.
- Constructed cuvettes around all of the newly planted olive trees in zones 2 and 3, and around 240 ha of already planted olive trees in zones 1-3. As a result, all trees now have cuvettes.

- Protected newly planted olive trees using 4 paid guards.

- Applied 0.5 kg ammonium sulfate fertilizer to 21,700 newly planted olive trees in zones 2 and 3.

- Purchased modern agricultural management tools for spraying, pruning, sawing, cutting, and plowing olive trees. These tools will be loaned to project cooperators.

- Stabilized 1.5 km of ravines in zone 1 using 5,000 acacia plantings.

- Distributed 24 Spanish goats to cooperators in zones 1-4.

- Reseeded 12.5 ha of degraded private rangeland in zone 2 with grass forage.

- Developed a Geographic Information System database for estimating erosion in Oued Nakhla before and after project interventions.

- Reduced erosion on dryland olive tree plantings by an estimated 52 tons/ha, or 28,413 tons for the entire planted area.

- Conducted a workshop for project participants dealing with lessons learned.

Table 3: Indicators of Project Success

Indicator	Target	Actual Quantity
ü Sign Workplan Agreement with	1	1

Table 3: Indicators of Project Success

Indicator	Target	Actual Quantity
Project Partners		
ü Olive Tree Plantings	42,000	21,700
ü Cuvette Construction	143 ha	110 ha
ü Hire Guards for Trees	4	4
ü Buy fruit trees for terraces	5,000	10,000
ü Grass Strips Between Trees	170 ha	2 ha
ü Reduced Erosion	25%	25%
ü Number of farmers and families trained in conservation techniques	-	398+
ü Number of workshops and training sessions	9	11
ü Distribute cookstoves	8	-
ü Planting of ravines	1.5 km	1.5 km
ü Distribute Spanish Goats	25	24
ü Reseeding Rangeland	100 ha	12.5 ha
ü Beekeeping Operations	100	100
ü Rehabilitate Mattoral	24,000 trees	-
ü Plan for Irrigation Canals	zone 1	zone 1

7. Recommendations for 2001 Workplan

As noted above, the project has achieved good success in its third full year of activity. Several recommendations are given below to improve the project even further. The 2001 Workplan presented in the following section is consistent with these recommendations.

- Improve partnership and communication between the PREM team, the National Coordination Committee, and the DREF regarding restoration of the mattoral.

- The DPA Work Center personnel should place additional effort in monitoring and managing the improved Spanish goats placed in the watershed. Castration of un-improved goats is important.

- Place a high priority on actvities that involve the education of women and reduce their consumption of wood collected in the mattoral. Similarly, it is important to stimulate income generating activities for women that involve micro-credits for small animal production, bread making, and handicraft production.

- Establish grass or alternative forage crop buffer strip demonstration plots along the contour between planted trees in zones 1, 2, and 3. Develop a strong education program to encourage widespread adoption of grass buffer strips.

- Develop additional sources of water for trees during summer in zones 2 and 3.

- Plant oleanders and acacias in ravines of zone 1 and 2. Slumping ravine banks are producing significant quantities of sediment.

- Improve the efficiency of collection and analysis of data from the erosion plots, which has been hampered by a lack of quality labor qnd maintenance problems. Refine the GIS datalayers used in estimating project impacts on soil erosion.

- Initiate a series of activities and workshops dealing with project replication and dissemination.

8. Workplan for 2001

The Workplan for 2001 has been modifed to account for progress made on the project during 2000. The Workplan includes the following activities:

1. Project Partnership Coordination
2. Implementation of Direct Actions
3. Implementation of Indirect Actions
4. Education and Training
5. Project Monitoring and Reporting
6. Project Replication Activities

A timetable for project activities is given below (Table 4).

TABLE 4 : IMPLEMENTATION TASKS FOR SOIL EROSION CONTROL PILOT PROJECT IN 2001

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Project Partnership Coordination and Development												
Meetings of National Coordinating Committee												
Meetings of Local Implementation Committee and Community Associations												
Sign Sub-Contract with DPA for Direct Interventions and DREF for Indirect Actions												
Meeting with NGOs to Sign Sub-Contract for Indirect Interventions												
Form Beekeeping Associations in Zone 4												
Form Womens Educational Association in Zones 2-3												
Implement Direct and Indirect Interventions												
Plant 30,100 Olive Trees on 215 ha and Build Cuvettes Around Them beyond Zone 3												
Maintain Cuvettes Around Existing Olive Trees in Zones 1-3												
Plant Buffer Strips Along the Contour Line Between Trees on 6 ha in Zones 1-3												
Continue to Hire Guards to Protect Planted Trees from Grazing in Zones 1-3												
Develop 9 Additional Water Reservoirs for Planted Olive Trees in Zones 2-3												
Plant 5,000 Oleanders or Acacias Along Failing Banks for 5 Ravines in Zone 1												
Plant 5,000 Oleanders or Acacias Along Failing Banks for 2 km of Ravines in Zone 2												
Distribute 26 Spanish Goats in Zones 1-3; Castrate Existing Non-improved Male Goats												
Plant Grass on 30 ha of Private Rangeland in Zone 2 and on 30 ha in Zone 3												
Plant 8,000 Carob & 16,000 Acacia Trees on 90 ha Degraded Mattoral in Zones 1-4												
Rehabilitate 2 km Irrigation Canals in Zone 1												

Plant 10,000 Fruit Trees on Irrigated Terraces in Zone 1												
Distribute 26 Cooperative Improved Efficiency Cookstoves in Zones 1-4												
Distribute 125 Cooperative Bee Hive Units in Zone 4												
Conduct Training on Management Techniques												
Workshops on Restoring Cuvettes in Zones 1-3												
Workshops on Installing and Maintaining Buffer Strips in Zones 1-3												
Workshops on Erosion/Water Storage/Crop Productivity Relationships in Zones 1-3												
Workshops on Goat Production and Management in Zones 1-3												
Workshop on Beekeeping Production and Management in Zone 4												
Workshops on Farm Equipment Usage and Maintenance in Zones 1-3												
Workshops on Disease and Pest Control in Olives in Zones 1-3												
Workshops on Restoration of Degraded Rangeland and Mattoral in Zones 1-4												
Workshops on Efficient Irrigation Management Techniques in Zone 1												
Demonstrations on Wheat, Forage, Olives (Tillage, Planting Rate & Timing, Fertilizer)												
Field Trips for Cooperators to Moroccan Sites												
Field Trips for Work Center Technicians to Moroccan Sites												
Workshops on Cookstoves, Small Animal Production, and Handicraft Skills for Women												
Monitor Progress of the Pilot Project												
Collect and Summarize '98-'99, '99-'00, and '00-'01 Erosion Plot Monitoring Data												
Improve Erosion Parameters and Erosion Rate Estimates for GIS Datalayers												

Monitor Sediment Trapping Efficiency of Buffer Strips, Cuvettes, and Check Dams												
Conduct Workshop to Review Erosion Monitoring and Assess Reductions in Erosion												
Quarterly and Annual Reports of Project Progress												
Replication of the Pilot Project												
Dissemination Workshops About Project for Farmers, Politicians, Agencies, Technicians												
Handbook on Procedures for Project Replication												
Handbook on Lessons Learned from Project Activities												
Feasibility Study for Project Replication												
Action Plan for Project Replication												
Implementation Plan for Project Replication												

8.1: Project Partner Coordination

8.1.1: Contractual Relationships

Regular meetings are required among project partners and various project committees to track project progress, plan and coordinate project implementation activities, and solve problems that may arise. The National Coordinating Committee and the Local Implementation Committee should meet quarterly, at the least. A sub-contract should be signed by January or February with the DPA and other PREM partners to execute all of the direct actions listed in Table 4. PREM team members should organize meetings with Moroccan Agencies and NGOs who will be involved with implementation of the indirect project actions and sign sub-contracts with them to implement indirect actions. These include the Regional Department of Water and Forests (DREF), the Agency for the Development of Northern Provinces, the Associacion Tetouani de Iniciativas Sociolaborales (ATIL), the Instituto de Promocion y Apoyo al Desarrollo (IPADE), and the Association pour la Protection de l'Environment et le Developpement de la Wilaya de Tetouan (APET).

8.1.2: Formation of Women's Educational Association in Zones 2-3

Women spend considerable time and effort collecting wood in the mattoral regions for cooking, heating water, and feeding animals during the winter. Stoves used to burn wood are very inefficient, thus leading to increased degradation of the mattoral. Improved efficiency cookstoves in the ATTC project have been shown to reduce the consumption of wood by 38%, and reduce the time women spend collecting wood by 375 hours annually. The PREM project should work with consultant Fatima Zahid to develop Women's Educational Associations in Zones 2-3. These Associations would discuss issues related to reduced wood collection and improved efficiency cookstoves. The Associations would develop a plan for utilizing 26 improved cookstoves in Zones 1-3. The Association in Zone 1 would be given micro-credits to allow for financing of income generating activities such as raising small animals (chickens or rabbits), and making handicrafts (shoes, dresses, jewelry, artwork, etc.).

8.2: Implementation of Direct Actions

8.2.1: Olive Tree Plantations

Olive trees with cuvettes were planted in the year 2000 on 110 ha in zones 2 and 3. In the process of planting wheat, these cuvettes were destroyed by cultivation. Cuvettes are to be re-constructed on all of this land around trees in 2001. It is very important that this re-construction take place early in the rainy season, rather than after harvest, to enhance the collection of water and sediment by the cuvettes.

An additional 30,000 olive trees should be planted on 215 ha beyond zones 1-3 during 2001. These trees are an extension of project activities stimulated by greater than expected villager desires for olive trees. Some of these trees should be used to replace dead trees from plantings in previous years.

Buffer strips consisting of grass forage (dactylis) should be installed along the contour line between planted fruit trees in zones 1, 2, and 3. The areas targeted for this activity in 2001 are 2, 2, and 2 ha, respectively, in zones 1, 2, and 3. The buffer strips should be at least 1 m wide, and preferably 2 m wide. These areas will be protected from grazing for at least one and a half years. Farmers should be compensated for the loss of wheat production that these strips cause. Since grass planting coincides with planting of wheat, PREM and its partners should hire laborers to seed the grass strips after farmers have tilled the land.

Guards should continue to protect the planted olive trees and buffer strips in zones 1, 2, and 3 from grazing. During the fall and early winter, villagers should be provided with fodder for their animals, to alleviate the lack of grazing land associated with olive tree plantations.

Water resources will be developed in zones 2 and 3 to assist villagers in irrigating newly planted olive trees. DPA will execute the development of these resources. At least 9 new reservoirs should be constructed during the spring and early summer before dry weather causes water stress in olive trees.

8.2.2: Stabilization of Ravines

Five ravines stabilized by Brahim El Hilali in zone 1 during 1999 are to be stabilized further by planting additional oleanders and acacias along the banks. Stabilization will involve planting at least three rows of plants during the spring along the ravine banks between gabions and check dams. Plantings should focus on banks that are bare of vegetation, to reduce the potential for further bank slumping along ravines. An additional 2 km of ravines in zone 2 should be stabilized by dense plantings of acacias or oleanders.

8.2.3: Rehabilitation of Irrigation Canals and Fruit Tree Planting in Zone 1

The CPS has issued a bid and workplan for rehabilitation of 2 km of irrigation canals in zone 1. The work will focus on the delivery of water from the spring to the irrigated terraces, not on rehabilitation of the irrigation networks within the irrigated terraces. Work on this project should commence during March of 2001.

8.3: Implementation of Indirect Actions

8.3.1: Improved Management of the Mattoral Zone

Social attitudes towards grazing of public mattoral currently prevent the widespread sowing of forage grasses in mattoral zones as envisioned in the project proposal and 2000 workplan. PREM should hire a sociologist familiar with agricultural land use and rangeland issues to meet with villagers concerning the issue of forage grasses in public mattoral zones. Perhaps the sociologist can develop a set of procedures for reseeding a portion of the public mattoral with forage grasses that are socially acceptable to all villagers. PREM should also meet with the DREF to sign a contract with them to develop a plan for restoration of the public mattoral zones.

If a set of socially acceptable procedures for reseeding public mattoral with forage grasses can be developed, then fescue (Festuca elatior L.) should be planted on 90 ha of the public mattoral, with 60 ha near Bettara, 15 near Achekrade, and 15 ha near Zerka. Sowing should occur during the autumn at a rate of 15-20 kg/ha, and a depth of 2-3 cm. Newly germinated grass will be protected from grazing for a period of one and a half years.

Roughly 8,000 carob and 16,000 acacia tree seedlings provided by the DREF from the Sodea nursery should be planted on 660 ha of public mattoral in zones 1-4. Planting density will be approximately 36 trees/ha (20 m spacing between trees). No surveying is necessary to identify planting zone locations. These trees are not likely to be destroyed by direct animal grazing. Educational sessions should be conducted with villagers to stress the importance of not using newly planted trees for firewood or animal feed.

8.3.2: Improved Management of Private Rangeland

Forage grasses should be planted on 30 ha of private rangeland in zone 2 and 30 ha in zone 3. Seeding would be at a rate of 15-20 kg/ha, and at a depth of 2-3 cm during the months of Novemer through February. Restored rangeland should be planted with 50 acacias/ha around the perimeter of each parcel restored. Agreements should be signed with cooperators to protect these areas from grazing for a year and a half. Cooperators should be taught to harvest the forage grasses and store them until animal feed is needed during the winter months or during drought.

8.3.3: Improved Goat Production

Improved Spanish goats have been distributed to 24 farmers in zones 1-4. The DPA should follow up on these goats to monitor changes in reproduction, nutrition, and general health. Non-improved male goats in the herd should be castrated.

Twenty six additional Spanish goats are in quarantine until blood tests show that they are healthy. These goats should be fed a balanced diet consisting of forages, composite nutritional feed, and straw until they are ready to be distributed in Oued Nakhla. Farmers in zones 1-4 having less than 25 goats each will be provided with one of these improved goats. Contracts should be signed with these cooperators to ensure that males from crossbreeding will be sold before they reach puberty to avoid excessive herd size.

8.3.4: Improved Fruit Tree Production on Irrigated Terraces in Zone 1

Farmers in zone 1 have been surveyed to determine what types of fruit trees they wish to plant along the contour on their irrigated terraces. The DPA will provide roughly 10,000 fruit trees for planting on irrigated terraces in zone 1 during the period from November, 2000 to March, 2001.

The farmers who benefit from this project should sign contracts to the effect that the extra income they receive will not be used to intensify up and down slope tillage or phosphorus

fertilizer applications in crop production areas on rainfed lands planted with olive trees. This will ensure that delivery of sediment and phosphorus to the Oued Nakhla Reservoir will continue to decrease.

8.3.5: Improved Efficiency Cookstoves

The Work Center has determined that it is feasible to distribute 26 improved efficiency cookstoves in zones 1-4. A micro-credit should be provided to each cooperator to initiate a program of collective bread baking. In this program, a collective of women would be formed for each cookstove. Each woman in the collective would have shared responsibilities for bringing wood to fuel the cookstove. One woman would be responsible for baking the bread, and selling it to cooperators at a reasonable price.

Greater involvement of NGO's should occur in association with the cookstove project. NGO's that could be involved include the GEF RIF and IPADE in Chefchaouen.

8.3.6: Cooperative Bee Keeping Associations in Zone 4

Drought has diminished the motivation of 25 cooperators involved in the Bee Keeping Association in zone 4. Efforts are needed to replace the 25 hives lost due to drought and disease, and introduce an additional 100 hives. A second Bee Keeping Association should be formed to manage the second set of 100 hives.

8.4: Education and Training

8.4.1: Workshops on Installing and Maintaining Grass Buffer Strips

PREM consultants and the DPA Work Center personnel should instruct farmer participants in zones 1, 2, and 3 on benefits of buffer strips, and methods for their installation and maintenance. A demonstration of these installation techniques will be included on 2 ha of land in each zone. Farmers from each zone will be taken to these demonstration plots to learn about their benefits to soil conservation and forage production.

8.4.2: Workshops on Re-Constructing Cuvettes

PREM consultants and the DPA Work Center personnel should instruct farmer participants in zones 1, 2, and 3 on the importance of cuvettes for collection and storage of water, and methods for their re-construction and maintenance after tillage. It is very important to re-construct cuvettes soon after tillage and wheat planting, rather than after harvest of wheat. A demonstration of these construction techniques will be included.

8.4.3: Workshop on Erosion/Water Storage/Crop Productivity Relationships

PREM consultants should instruct farmer participants in zones 1, 2, and 3 on the relationships between erosion control, improved water storage in cuvettes, and productivity of fruit trees

and rainfed cultivated crops. This workshop should stress the economic benefits to farmers of controlling erosion and conserving water. This workshop could be held in conjunction with the workshop on cuvettes.

8.4.4: Workshops on Goat Productivity Management

PREM consultants, and DPA Tetouan or DPA Work Center personnel should instruct farmer participants in zones 1-4 on the proper techniques for improving goat productivity. These include benefits of improved breeding stock, sales techniques, avoiding cross-breeding through castration, culling the herd, optimizing live weight rather than total number of animals, caring for young goats, disease identification and management, nutrition, rotational grazing, and storage of fodder.

8.4.5: Workshops on Bee Management

PREM consultants, the Agency for Development of the Northern Provinces, the ATIL cooperative in Tetouan, and the DPA Work Center in Beni should instruct zone 4 participants in improved beekeeping techniques. These include feeding techniques, inspecting and cleaning hives, collection of honey, breeding, multiplication of colonies, swarming, harvesting, and equipment operating procedures, maintenance, and repair. Supplemental food should be provided for bees in the event of continuing drought.

8.4.6: Workshops on Farm Equipment Use Techniques

The DPA Work Center should instruct farmer participants in zone 1 on proper methods for using, maintaining, and repairing pruning shears, saws, sprayers, and threshing machines.

8.4.7: Workshops on Disease and Pest Control in Olive Trees

The DPA Work Center should hold workshops in each of zones 1-3 on identification and control of diseases and pests in olive trees. The workshops will also describe proper methods for spraying chemicals, including personal safety and environmental protection.

8.4.8: Demonstration Trials on Wheat, Forage, and Olives

The DPA Work Center has already established demonstration trials in zones 1-4 to illustrate proper management techniques for wheat, forage, and grass strips. Demonstrations typically involve trials with various types of tillage, fertilizer management, and varieties of crop in comparison with typical farmer practices. Farmers should be taken to demonstration sites near harvest time to see the improvements in crop yield using good management practices.

Additional trials will be established for olive tree management practices. These trials should stress grass buffer strips, fertilizer management, pest and disease management, pruning, and the use of cuvettes for improved water uptake.

8.4.9: Field Trips for Project Cooperators and Technicians

As the project progresses, several technical questions will undoubtedly arise concerning olive trees, fruit trees, forages, goats, bees, and erosion control. A program for updating the knowledge of project cooperators and Work Center technicians is needed. One aspect of this program should involve field trips to sites where improved management techniques can be demonstrated. Examples of sites within Morocco where new information can be learned would include visits to ENA Meknes and Hassan IAV extension centers, visits to Kenifra or Ouezzane, and visits to mattoral restoration projects, rangeland restoration projects, and to olive tree, fruit tree, goat and beekeeping projects.

8.4.10: Workshops and Field Trips for Womens's Associations

The Women's Educational Associations in zones should visit sites in Morocco where they can learn more about improved efficiency cookstoves, small animal production (chickens and rabbits), and handicrafts (shoes, dresses, jewelry, art, etc). Examples for visits about cookstoves include the Near East Foundation work in southern Morocco, IPADE in Chefchaouen, and the GEF RIF project. In addition, women should discuss the impacts of their cooking practices on health of the mattoral region, and on wood cutting activities. Women should be taught responsible wood cutting practices, and should not abuse the new pruning shears, saws, and axes loaned by the Work Center. Examples for visits about handicrafts would include the Ensemble Artisinale Training Center in Tetouan.

8.4.11: Workshops on Improved Management of Public Mattoral

The DREF, in conjunction with PREM and the DPA, should develop a plan for educating farmers about the economic and environmental benefits of proper management in the public mattoral. This plan should involve the importance of collective action, the need for reseeding and planting trees, and the need for protection of replanted areas from grazing. Workshops are needed in all four zones.

8.4.12: Workshops on Improved Management of Private Rangeland

PREM consultants and the DPA Work Center should conduct workshops and demonstrations on the economic and environmental benefits of improved management of private rangeland in zones 2 and 3. These workshops should focus on techniques for reseeding, temporary protection from grazing, forage production rates, and impacts on erosion.

8.4.13: Workshops on Improved Irrigation Techniques

Work Center technicians and PREM consultants should conduct a workshop on improved irrigation techniques in zone 1. This workshop would cover topics such as maintenance of irrigation networks, water requirements of different crops, symptoms of water stress, and strategies for efficient delivery of water.

<u>8.5: Project Monitoring and Report Writing</u>

8.5.1: Soil Erosion Plot Monitoring Data

PREM consultant Dr. Tayaa and the DREF have established 14 soil erosion plots to estimate the impacts of project activities on soil loss. Cultivated plots are not representative of surface cover conditions in typical dryland farmer fields. These plots should be sprayed with glyphosate to control bermudagrass, and then tilled. Following tillage, they should be planted with wheat. Runoff and erosion from plots should be collected in a timely fashion by DREF personnel for analysis of sediment losses.

8.5.2: Improved Estimates of Erosion Prediction Parameters

Data from erosion plots should be analyzed using standard procedures to obtain improved estimates of the cropping system factor (C). This improved parameter estimate is needed to estimate the impacts of project activities on soil erosion.

8.5.3: Geographic Information System (GIS) Data Coverages

Mr. Khatouri has made excellent progress in developing thematic layers dealing with Oued Nakhla. These layers can be used to improve the visualization of project activities, estimate impacts of the project on erosion and sediment delivery to Oued Nakhla, and to assist in dissemination of project results. Additional work is needed on analysis of some layers to improve the accuracy of erosion predictions. Some of the activities involved in this work include incorporation of a permeability factor to be used in estimating soil erodibility, modification of slope length and steepness factors on steep non-agricultural land and on irrigated terraces, incorporation of alternative cover management factors to account for short- and long-term effects of olive tree plantations and grass strips between trees, and accurate delineation of the boundaries for areas of olive plantings, improved rangeland, and improved mattoral.

8.5.4: Monitoring Impacts of Cuvettes, Buffer Strips, and Check Dams

Student helpers should collect data to quantify the amount of sediment retained in cuvettes, buffer strips, and check dams installed by the project. Metal pins or rods with graduated marks for measurement of depth should be placed in several (50) cuvettes, buffer strips, and check dams across zones 1-3 to facilitate quantification of sediment trapped by each action. These pins should be installed at the start of the rainy season, and observed monthly to determine rates of sediment accumulation.

8.5.5: Estimating Project Impacts on Reductions in Soil Erosion

A meeting of PREM project consultants should be convened to discuss progress towards estimating project impacts on reductions in soil erosion. This meeting will address erosion plot data, improved erosion prediction parameter estimates, GIS datalayer coverages, and quantification of sediment trapped by cuvettes, buffer strips, and check dams. An analysis of

these data will be conducted for a preliminary estimate of project impacts towards indicators.

8.5.6: Quarterly and Annual Reporting of Progress

PREM team members and consultants will make quarterly and annual reports on project progress to USAID. Indicators of project success are provided in Table 5.

Table 5: Pilot Project Indicators of Success

Year Four	ü Track number of meetings of Coordinating and Implementation Committees ü Track number of Community Association Meetings ü Track number of sub-contracts signed with DPA, DREF and NGOs ü Track number of Women's Education Association Meetings ü Track area of cuvettes maintained ü Track area planted to olive trees and number of trees planted ü Track area of land with buffer strips installed ü Track length of ravines stabilized with acacias ü Track number of guards hired ü Track number of water sources developed ü Track hectares of mattoral and rangeland improved, number of trees planted ü Track number of goats provided, treated, castrated ü Track number of cookstoves provided ü Track number of cooperative bee hive units provided ü Track number of fruit trees planted on irrigated terraces ü Track length of irrigation canals rehabilitated ü Track number of improved farm equipment provided ü Track number of farmers and families trained in improved management techniques ü Track number of workshops and training sessions held, and number of participants ü Continue development of accurate GIS thematic map layers to be used in estimating impacts of project interventions on erosion ü Improved parameters for the Wischmeier equation using data from erosion plot experiments and other data ü Installation of erosion pins in cropland, ravines, and matorral ü Estimate reduction in erosion from project actions ü Quarterly and annual reports of progress

8.6: Project Replication Activities

8.6.1: Handbook on Lessons Learned

Dr. Swift and Dr. Rachidi will take the lead in writing a Handbook on Lessons Learned from the Oued Nakhla Project. This Handbook will be loosely based on a workshop by the same title held in Meknes during November of 2000. The Handbook outline will include chapters on Successes Encountered, Difficulties Encountered, Building on Successes, and Overcoming Difficulties. For each chapter examples will be given concerning Institutional Arrangements, Direct Inverventions, and Indirect Interventions. Rather than focussing on specific actions taken, the Handbook will emphasize the approaches or methodologies used and results achieved. The audience for this Handbook includes USAID partners.

8.6.2: Handbook on Procedures for Project Replication

Dr. Swift will take the lead in editing a Handbook written by PREM consultants dealing with Procedures for Replication of the Project. The Handbook will be titled: "Sustainable

Development in Mountainous Areas of the Mediterranean Region." It will focus on the approaches and methodologies used in the Oued Nakhla project. The major chapters will include an Introduction, Project Rationale, Site Selection, Participatory Approach, Implementation Activities, Education and Training, Monitoring of Progress, and a Case Study highlighting specific actions.

8.6.3: Dissemination Workshops

Several workshops will be convened to disseminate project successes to various stakeholders. These stakeholdeers include Work Center technicians, farmers in adjacent watersheds, decision makers in key political positions, scientists at ENA and IAV, and agency personnel from the DPA, DREF, and DOE. The purpose of these workshops will be to create additional expertise and motivation for replication of project activities.

Content of the workshops will be based largely on the information contained in the two handbooks discussed above (replication procedures and lessons learned handbooks). Workshops could focus on the themes of "Watershed Management," "Participatory Landscape Lifestyle Appraisal," "Site-Selection Criteria," "Lessons Learned on Multi-Institutional and Multi-Disciplinary Coordination," "Lessons Learned on Direct Interventions," "Lessons Learned on Indirect Interventions," "Monitoring Progress," and "Education and Training."

8.6.4: Feasibility Study for Project Replication

Additional money is available from PMVB and USAID to replicate project activities at other sites in Morocco. A feasibility study will be completed to determine where such replication is likely to be most effective, and what specific action and implementation activities could occur. Other watersheds adjacent to Oued Nakhla, such as Oued Laou, or having similar characteristics will be considered. Watersheds having different physical and climatic characteristics, such as the Souss-Massa, will also be considered.

Factors to consider in the feasibility study include impact of the target area on degradation of soil and water resources, availability of willing government partners, availability of baseline data on which to base site selection, and the socio-economic context of the target watershed. After selection of a promising watershed for replication of project activities, potential partners will be mobilized and an implementation plan will be developed for specific direct and indirect interventions, including a cost-benefit analysis.

Replication of the Nakhla project in Oued Laou has a high feasibility, and will be rather direct and effective, considering the similarities between the two watersheds. Like Oued Nakhla, Oued Laou has fragile soils and degraded mattoral which contributes large quantities of sediment by water erosion. Much of the erosion originates in poor management of the soils and landscapes, whether from rainfed agriculture, grazing, or wood collection activities. Within Oued Laou, a first step in project replication would be selection of a small sub-watershed where local agencies and farmers are willing to cooperate and participate in a watershed management project.

Replication of the Nakhla project in the Souss-Massa would focus primarily on the application of methodologies learned. The Souss-Massa is characterized by a wide range of conditions, including precipitation which ranges from 250 mm/yr in the coastal and riverine lowlands to over 700 mm/yr in the forested regions of the Anti-Atlas and High Atlas mountains. Wind erosion leading to desertification is the primary mechanism of soil degradation in the coastal plains, while water erosion leading to in-filling of the Ibn Tachfine Reservoir is a problem in the forested mountain regions. Argane forests are a unique feature of this region, and their existence is threatened by over-grazing. Much of the coastal region is in highly productive irrigated vegetable production, and soil salinization is a threat to soil quality.

Wind erosion is caused by the saltation and suspension of soil particles under windy conditions. It is most serious in dry, poorly aggregated soils which are smooth and have little surface cover. When the wind can blow uninteruppted for long distances over such soil, huge quantities of sediment can be transported from the coastline towards the inland regions where vegetable production occurs.

Wind erosion (E) can be estimated using the Wind Erosion Equation:

E = function of (I', K', C', L', V')

where

I' is an index of soil erodibility
K' is a surface roughness factor
C' is the wind velocity and climate factor
L' is the length of field factor
V' is the cover factor

Wind erosion can be reduced by any of the following approaches. Approaches that increase soil erodibility through improvements in soil aggregate stability by additions of organic matter or biosolids to the soil will reduce erosion. Approaches that increase surface roughness through tillage perpendicular to the prevailing wind direction will reduce erosion. Approaches that reduce the effective length that the wind blows over the field by planting windbreaks will reduce erosion. Approaches that increase the level of soil cover through improved crop residue management or placement of woody matter on the soil surface will reduce erosion.

In the coastal region of the Souss-Massa, the most effective means of controlling wind erosion involve placing small branches on the soil surface perpendicular to the direction of the prevailing wind, and planting windbreaks of eucalyptus or acacia trees. The primary limitation in the former case is the availability of wood, while in the latter case it is moisture to grow the trees.

Both of these problems can be addressed by improving the delivery of irrigation water to the unstable sand dune areas where windbreaks are to be planted. Use of high quality irrigation water from Ibn Tachfine Reservoir is not recommended for this purpose, as it is already in short supply for the vegetable producing areas along the coast.

As an alternative, the feasibility of using treated wastewater and biosolids from Agadir should be explored as an alternative method for fostering extensive plantation of windbreaks along the coastal regions of the Souss-Massa near Tifnit where wind erosion is a problem. Technical factors to consider include the possible salinization of soil after long term application of treated wastewater, the tolerance of eucalyptus and acacia to such wastewater, and the impacts of biosolids on restoration of soil quality and aggregate stability in areas with unstable dunes.

As in the Oued Nakhla project, we would use the following methodology:

- Collect baseline physical and climatic data, developing a Geographic Information System for improved visualization, targetting, and tracking of project
- Conduct a series of participatory workshops with important stakeholder groups
- Identify potential project partners and technical experts
- Evaluate the technical feasibility of the windbreak project
- Evaluate the costs and benefits of the windbreak project
- Select a site for implementation of project
- Develop goals of project with interested stakeholder groups
- Develop action plan for project
- Develop implementation plan for project
- Develop monitoring plan for project
- Implement and monitor project activities